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EFFECT OF TIME OF APPLICATION OF MANURES.

By

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The experimental details of this series of trials are given fully in the appendix.

About 3½ acres of tea, planted in 1920, and similarly treated since, were divided into six equal areas such that each of the six had given practically the same yield in 1926, 1927 and 1928. It is fair to assume therefore that each of the six areas would have yielded about the same crop in 1929 if treatment had remained the same, and that differences appearing after different treatments in 1929 are due to the effects of these treatments.

One of the six areas was left unmanured, while each of the other five received the same manure, but at different dates.

The manure mixture used was :—

Sulphate of ammonia	...	200 lbs. per acre.
Sulphate of potash	...	60 ,, ,, ,,
Superphosphate	...	140 ,, ,, ,,

The results obtained in 1929 were :—

Date of application of manure.	Mds. Tea per acre.	Increase due to manuring.
Nil	8·06	.....
February 15th	10·75	2 69
March 27th	10 65	2·59
May 6th	10·47	2·41
June 17th	10 82	2·76
July 27th	9·97	1·91

The increases obtained from application of manure at any time between February 15th and June 17th are the same within the limits of the error of the experiment (see Appendix).

Application so late as July 27th gave a significantly smaller increase.

On the accompanying curves the actual weight of green leaf (in lbs.) taken at each weekly plucking is plotted against the date of plucking. For comparison, curves for the unmanured area are plotted on the same sheet with the curve for each manured area.

It will be observed that the curves for the areas manured in February and March are practically the same. Whether manure was applied on February 15th or March 27th, increase in crop is observed as soon as the weight of leaf plucked becomes significantly great. In both cases the good effect of the manure is marked right up to the end of the season.

In the case of the area manured on May 6th (curve No. 3), it will be observed that the crop curve is practically the same as that for the unmanured plot up to June 7th, but that on June 14th, the effect of the manuring shows up in a sharp increase in crop, 40½ lbs. being taken from the unmanured area, and nearly 60 lbs. from the manured area; an increase of about 50%. This great increase is not maintained, but very significant increases are observed in every week for the remainder of the season.

In the case of the June application (curve No. 4), the curve is the same as that for the manured area up to about June 14th, but small increases in crop occur on June 21st and 28th before the manures can be expected to be exerting any effect. These small increases probably are due to experimental error. After June 28th, the June manuring shows a steadily increasing yield compared to the unmanured yield. No sudden sharp increase on a definite date is observed as it was in the case of the May application, but on July 12th (four and-a-half weeks after application of manure) 50 lbs. of leaf were taken from the manured area as against 36 lbs. from the unmanured area. This increase of about 40% is certainly much too great to be possibly due to experimental error, so that the effect of the

manure in this case is seen about four weeks after application of manure. After that time the area manured in June yields steadily about 25 lbs. (or about 25 seers leaf per acre) more than the unmanured area at each weekly plucking almost till the end of the season.

The crop curve for the application of July 27th, (curve No. 5) is substantially the same as that for the unmanured area up to August 9th with the exception of June 14th, and July 26th, when the area subsequently manured gave respectively 7 lbs. more and 7 lbs. less than the unmanured area. The differences on these two dates can only be assigned to experimental error. On August 16th (only three weeks after application) the manuring results in a sudden sharp increase in crop, amounting to about 20 seers green leaf per acre, and the weekly increase in crop becomes still greater over the following weeks.

It will be seen from comparison of the crop curves that the increases in crop late in the season are not much greater after late manuring than after early manuring, except for a short period after the manure first shows its effect.

This may be seen more clearly from the following tables.

Total green leaf per 1080 bushes plucked in period :—

Date of Application.	Before May manuring shows effect. 29th March to June 7th (11 weeks)	Before June manuring shows effect. 14th June to 5th July (4 weeks)	Before July manuring shows effect. 12th July to 9th Aug (5 weeks)	Before marked effect of July manuring wears off. 16th August to 6th Sept. (4 weeks)	Before heavy flushing ceases. 6th Sept. to 2nd Nov. (8 weeks)	Light flushes at end of Season. 9th Nov. to 30th Nov. (4 weeks)
Nil	107	141	248	299	576	84
February 15th ...	161	179	332	355	725	98
March 27th ...	156	171	329	364	722	94
May 6th ...	112	187	314	366	725	95
June 17th ...	102	154	356	371	773	103
July 27th ...	103	152	242	380	743	108

Increased crop in lbs. green leaf per 1080 bushes due to manuring in period :—

Date of Application.	29th March to 7th June.	14th June to 5th July.	12th July to 9th Aug.	16th Aug. to 6th Sept.	13th Sept. to 2nd Nov.	9th Nov. to 30th Nov.
February 15th ...	54	38	84	56	149	14
March 27th ...	49	40	81	65	146	10
May 6th ...	...	46	66	67	149	11
June 17th ...	...	...	108	72	197	19
July 27th ...	...	...	...	81	167	24

It will be observed from the last table that the figures for the manuring of February 15th and for March 27th (forty days later on) are practically the same. There was, then, no advantage from the earlier manuring, but neither was there any loss.

The May manuring had shown no effect up to June 7th, and the early loss of crop compared to results from earlier application is not made up during the remainder of the season. During the period June 14th to July 5th, the May manuring shows rather a greater effect than the earlier manuring, but there is a relative loss between July 12th and August 9th, which cannot be accounted for.

The June manuring shows no effect up to July 5th, but between July 12th and August 9th, the effect is much more marked than that of earlier manuring, and there is a further, and abnormally great, increase between September 13th and November 2nd, so that the crop over the whole season was rather greater than from manuring at any other date.

The July manuring showed no effect up to August 9th, and though it showed very great effect between August 16th and the end of the season, this part of the season was clearly not long enough to allow the full effect of the July manuring to be exerted. It is possible that some residual effect may be observed in season 1930.

The results of the experiment in the first year are seen to be not quite concordant. The results from the June manuring appear to be abnormally great between July 12th and August

ERRATUM.

On page 59 of Part II of the Quarterly Journal, 1930, for paragraph 3 kindly read :—

It may be guessed, however, that in general the greater effect for a short time after late manuring would not quite make up for the loss of early crop obtained from early manuring.

9th, and also between September 13th and November 2nd. The results from the May application appear to be unduly small in the period June 14th to August 9th. Such abnormalities may be due to difference in conditions at the time of application, or to differences in original fertility of the soil in spite of the precautions taken. The results from the applications of February, March and July appear to be about normal.

The great bulk of the increased crop is in all cases made in July, August, September and October. The July manuring which misses about six weeks of this period shows a definite loss compared to earlier manuring. Manuring early enough to be in action at the beginning of this period shows losses or gains due to date of application too small to be computed accurately from this experiment.

It may be guessed, however, that in general the greater effect for a short time after late manuring would not quite compared to earlier manuring. Manuring early enough to be manuring.

Manures do not appear to act until climatic factors (in this case mainly rainfall) become favourable to growth, so that there is a time before which nothing is gained by earlier manuring.

In this case for example, nothing is gained by manuring on February 15th rather than March 27th, 1929 was an early season so that we may assume that in the case of quick acting manures like sulphate of ammonia, we can count on obtaining their full effect if we apply them before the end of March, but there is no loss in efficiency from applying them in February if it is convenient to start the manuring then.

Manuring in May or June may, as in the case of this experiment, show little or no loss compared to manuring in February or March, *if all the leaf grown can be taken*. On gardens in practice, however, leaf is very commonly (one might say, nearly always) lost in the height of the growing season, so that in our opinion late manuring would not show as good results on the majority of gardens as it did at Borbhetta in 1929 when there was ample labour for plucking strictly, at weekly intervals.

There are very few gardens on which plucking is not as accurate as the manager requires up to the end of June. There is therefore a practical advantage in getting as much as possible of the increased crop from manuring, early in the season, from the point of view of crop.

With regard to quality, the position is not quite so clear. Second flush teas, which are obtained roughly up to July 5th (to which date the manuring of June 17th had shown no effect), are commonly much more valuable than teas made later, so that there should be an advantage in increasing the quantity of second flush tea rather than increasing the crop of less valuable mid-season tea. For this reason also the early manuring should show an advantage.

"June teas" of stand out flavour, however, are only obtained when the peculiar stunted growth appears, which is usually ascribed to green fly attack. Although this disease reduces crop seriously, the big price obtained generally more than compensates for the reduced quantity, except when growth almost ceases as it does during very bad attacks. When the disease fails to appear at all, as it did in many places in 1929, manuring is sometimes suggested as a possible reason. Judging from our experience at Borbhetta, however, the appearance of the "green fly" effect depends purely on unknown seasonal factors. When it has appeared (as it usually has at Borbhetta) it has attacked all plots about equally, however, manured; but one cannot deny the possibility that certain combinations of manures may enable bushes to remain free from the disease at least in some seasons. It is a matter on which very little evidence is available; but there is certainly not enough at present to justify the avoidance of early manuring from fear of losing quality in second flush teas.

From these experiments, as far as they have gone, one would advise that manures should be applied during February and March. It is possible that still earlier manuring may show as good results, but there is no experimental evidence on which a judgment on that point may be founded.

Variation in soil Nitrates.—Throughout the season weekly samples of the top 9 of soil were taken from each plot in each series with exception of series 2, and analysed for nitrate and ammonia contents. The results are plotted below the attached crop curves for the corresponding series. It will be observed firstly that the soil nitrates were high at the beginning of April for all plots, manured or unmanured, but by the end of April had fallen to about 2 parts per million on unmanured plots.

In the case of all the manured plots, there was a period during which the nitrate content was much higher than that of the manured plots, this period lasting for about 6 weeks only, whereas the crop increase was maintained in every case up to the season's end. This would seem to indicate either that the bush stores up nitrogen in some form, during a period of high soil nitrate content, for later use when the soil nitrate is low; or that soluble nitrogen is active in the soil below 9."

It will be seen from the curves that if manure (sulphate of ammonia) is applied while the soil nitrate is high, it does not appear to be nitrified until the soil nitrate reaches a low figure. If the manure is applied while the nitrate content is low, nitrification proceeds immediately. This is clearly seen from the curves. Thus in the March application, the nitrate content of the soil remained the same as the check plot, which was very high, until the end of April. When the nitrate in the unmanured soil had dropped to 2 or 3 parts per million, the manure began to be nitrified, and the nitrate content of the manured soil rose to 11 parts per million.

Manures applied in May, June and July, when the nitrate stands at a low figure, are nitrified at once. These observations are confirmed by those made by the Bacteriological Department, on fallow plots at Tocklai.

SUMMARY.

(1) Manuring at any time, between February 15th and June 17th, gave substantially the same increase in crop; but it

is probable that, in practice, rather larger crops would be made, and better average prices would be obtained from manuring before the end of March than from manuring later in the season. Manuring at the end of July was too late for the full effect to be exercised in the same season.

(2) The effect of manuring in February or March showed up in increased crop as early in the season as the weight of leaf obtained became significant.

(3) The effect of manuring on May 6th showed in increased crop about 5 weeks later.

The effect of manuring on June 17th showed about 4 weeks later.

The effect of manuring on July 27th showed about 3 weeks later.

Whenever applied, the effect of manuring on crop continued till the end of the season.

(4) Sulphate of ammonia is very slowly converted to nitrate in the soil, while the soil's natural nitrate is high; but as nitrate disappears from unmanured soil, the applied ammonia is rapidly nitrified even on the acid soil experimented with.

No increase in soluble nitrogen (ammonia or nitrate) compared to unmanured soil, was found in the surface soil after about eight weeks from application of manure. Marked crop increase, however, was obtained as much as 23 weeks after the added manure had disappeared from the surface soil. It is presumed that either (*a*) the bush can store nitrogen when plenty is available, for use late in the season, or (*b*) the manure remains active in deeper layers of soil.

In season 1930 this last point will be investigated.

APPENDIX.

Experimental details.

These experiments were carried out on about 3½ acres of tea planted in early 1921. This area was divided into 72 plots of

equal size, which were all treated exactly alike till the end of 1928.

The tea was medium pruned at 18" from the ground at the end of 1923, since when it has been top pruned, so that it may be considered now to be normal mature tea. Records of pluckings from each plot separately have been maintained.

The land before planting was very broken and full of holes and white-ant hills. The area now contains many bad patches of soil, due to white-ant hills (which are alkaline and grow tea very poorly), or to subsoil exposed in levelling high places (which subsoils are normally acid but chemically very poor). These bad patches reduce very greatly the yields of plots containing them. In places where holes were filled in, very largely with surface soil from surrounding high places, the soil is much better than on the soil of the average old grazing land of Borbhetta, where the good surface soil is very shallow. Plots containing such filled in holes therefore yield crops well above the average. Crops from the small plots therefore show very wide variation among themselves. Crop records show a tendency for the very good plots to fall towards the average; but individual plots have, on the whole, maintained their relative positions very well.

To get accurate results from such uneven plots it was considered necessary to repeat each experiment on twelve plots.

The effect of difference in season is liable to vary on different parts of the area.

The plots on higher land are relatively rather better in wet seasons and rather worse in dry seasons, than plots on lower land. Disease usually attack in patches, so that there is a tendency for neighbouring plots to be affected similarly. It is therefore necessary to secure even geographical distribution of the plots under the same treatment, in order to minimise differences in seasonal effects, and degree of attack by disease. The whole area was therefore divided into 12 blocks of 6 plots each.

The 72 plots were then divided into 6 series of twelve plots each, such that each block contained one plot of each series, and

such that the total yield of each series of twelve plots was the same in 1928. It was then found that each series yielded the same crop also in 1927 and 1926 within a small margin. The accompanying plan will make this clear. Since this method of selection was used it is not permissible to calculate the probable error of the experiment from the yield of individual plots.

We must look upon the experiment as having made upon six single composite plots each of which had yielded similarly for three years, and therefore was likely to have continued to yield similarly if treatment had remained similar. Any differences which appear after difference in treatment may therefore be ascribed to the effect of the treatment. A check on the accuracy of the results may, however, be obtained by considering the rise or fall of crop from each plot compared to its own yield in the previous year. The plots were selected with regard only to their yields in 1928, and not with regard to the rates of rise or fall in crop, so that in this respect the selection may be considered to have been hap-hazard.

The following table shows the detailed results for each plot :—

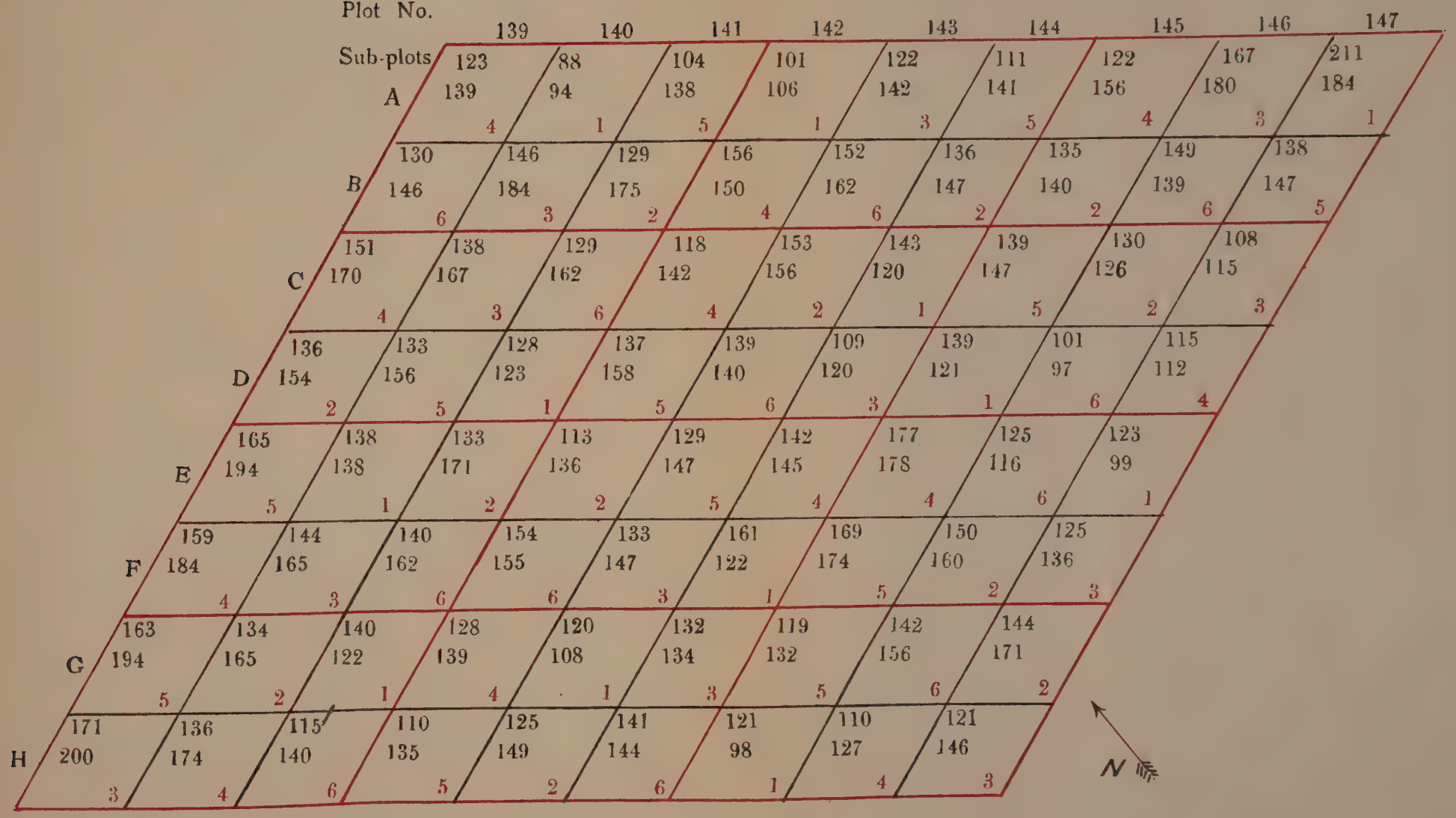
Yields in lbs. and ozs. green leaf per plot of 90 bushes.

Series 1. Unmanured.				Series 2. Manured February 15th.			
Plot No.	1928.	1929.	Difference.	Plot No.	1928.	1929.	Difference.
147a	210-12	184- 2	− 26-10	145b	134-12	140-12	+ 5- 6
147e	123- 3	98-15	− 24- 4	146f	149-14	159-10	+ 9-12
143g	119-15	107-11	− 12- 4	143h	124-11	148-12	+ 24- 1
144c	143- 2	119-14	− 23- 4	143c	151-15	155-11	+ 3-12
140e	138- 2	137-11	− 0- 7	141e	133- 1	170-10	+ 37- 9
140a	88- 4	94- 5	+ 6- 1	141b	128-12	175- 3	+ 46- 7
145h	121- 6	98- 0	− 23- 6	147g	143- 9	171- 7	+ 27-14
145d	139- 3	120- 9	− 18-10	146c	130- 4	126- 1	− 4- 3
144f	160- 9	122- 7	− 38- 2	142e	113- 1	135-11	+ 22-10
142a	101- 1	105-15	+ 4-14	144b	136- 2	147- 6	+ 11- 4
141g	140- 5	121-13	− 18- 8	140g	133-13	164-10	+ 30-13
141d	127-13	122- 9	− 5- 4	139d	136- 5	154- 6	+ 18- 1
Total	1,613-11	1,433-15	179-12	Total	1,616-3	1,849-9	233-6
Average loss per plot... ... 16 lbs.				Average gain per plot ... 19¼ lbs.			
p. e. of average loss ... ... 3 lbs.				p. e. of average gain ... 1⅞ lb.			

PLAN OF EXPERIMENTAL PLOTS

Figures in red indicate number of series

Series 1	No Manure		
„ 2	Manured	February	15th.
„ 3	„	March	27th.
„ 4	„	May	6th.
„ 5	„	June	17th.
„ 6	„	July	27th.



Figures in black show crop from plot to nearest pound.
Upper figure. in 1928.
Lower figure. in 1929.

Series 3. Manured, March 6th.				Series 4. Manured, May 6th.			
Plot No.	1928.	1929.	Difference	Plot No.	1928.	1929.	Difference.
146a	166-13	180- 5	+ 13- 8	145a	121- 8	135- 8	+ 14- 0
147f	125- 6	135-10	+ 10- 4	145e	177- 1	177-15	+ 0-14
144g	131-11	134- 5	+ 2-10	142g	128- 0	139- 4	+ 11- 4
144d	108-15	119- 8	+ 10- 9	142c	118- 3	141-14	+ 23-11
140f	143- 9	165- 1	+ 21- 8	139f	159- 1	184- 6	+ 25- 5
140b	145-14	183-10	+ 37-12	139a	122-10	139- 7	+ 16-13
147h	121- 6	146- 3	+ 24-13	146h	109- 8	127- 2	+ 17-10
147c	108- 3	115- 1	+ 6-14	147d	114- 8	111-11	− 2-13
143f	133- 2	147- 0	+ 14- 2	144e	141-14	144-13	+ 2-15
143a	121-11	141-10	+ 19-15	142b	136- 6	149-10	+ 10- 4
139h	171- 6	200- 6	+ 29- 0	140h	136- 0	174- 4	+ 38- 4
140c	137-13	167- 5	+ 29- 8	139c	150-11	170- 6	+ 19-11
Total	1,615-13	1,836-0	220-3	Total	1,615-6	1,796-4	180-14
Average gain per plot ... 18¼ lbs.				Average gain per plot ... 15 lbs.			
p. e. of average gain ... 2 lbs.				p. e. of average gain ... ... 2 lbs.			

Series 5. Manured, June 17th.				Series 6. Manured, July 27th.			
Plot No.	1928.	1929.	Difference.	Plot No.	1928.	1929.	Difference.
147b	137-10	147- 1	+ 9- 7	146b	148-13	138-12	− 10- 1
145f	168- 8	171- 1	+ 2- 9	146e	124-13	115-14	− 8- 9
142h	109-10	134-10	+ 25- 0	144h	140- 9	144- 5	+ 3-12
142d	137- 4	158- 4	+ 21- 0	143d	139- 4	139- 8	+ 0- 4
139e	164-11	194- 3	+ 29- 8	141f	140- 4	161-13	+ 21- 9
141a	103- 8	137- 9	+ 34- 1	139b	129- 8	146- 2	+ 16-10
145g	119- 4	131-10	+ 12- 6	146g	141-12	155-15	+ 14- 3
145c	139- 6	146-12	+ 7- 6	146d	100-15	97- 7	− 3- 8
143e	128-11	147- 0	+ 18- 5	142f	154- 2	154.12	+ 0-10
144a	110-14	141- 6	+ 30- 8	143b	152- 2	162- 0	+ 9-14
139g	162-10	194- 1	+ 31- 7	141h	115- 4	140- 0	+ 24-12
140d	133- 7	156- 1	+ 22-10	141c	129- 5	161-14	+ 32- 9
Total	1,615-7	1,859-10	244-3	Total	1,616-11	1,718-6	101-11
Average gain per plot ... 20 lbs.				Average gain per plot ... 8¼ lbs.			
p. e. of average gain ... ... 2 lbs.				p. e. of average gain ... ... 3 lbs.			

The differences made by manuring at any time are of course all significantly great. Manuring in February, March and June, resulted in average increase respectively of 19½, 18¼ and 20

lbs. per plot, the probable error of the average being in each case about 2 lbs. There is no significant difference between the results of these three treatments. The manuring of May 6th, 1929, gave 15 lbs. average increase per plot over 1928, the probable error of the average increase being 2 lbs. The probable error of the difference between May manuring, and manuring in February, March or June is about $4+4$ in each case or about 3 lbs., which last number is so little less than the differences between 15 and 19½, 18¼ or 20 that these differences cannot be considered as significant with any high degree of certainty.

The manuring of July 27th, 1929, gave only 8½ lbs. increase per plot over 1928 yields, which is 11, 6½, 9¾ and 11½ lbs. respectively less than the increases per plot obtained from manuring in February, March, May and June. These differences are all considerably greater than the probable error of the differences which is in each case $\sqrt{4+9}=$ about 3½; so that the July manuring gives significantly less increase in crop than earlier manuring.

THE FIRING OF TEA.

By

C. R. Harler.

Theoretical considerations.

Before considering the practical aspect of the firing of tea under factory conditions in North East India, it is proposed to describe briefly the chemical significance of the process and to indicate ideal drying conditions in the case of tea.

During the "fermentation" of tea leaf, the main chemical reaction consists of the oxidation of tea tannin by the aid of an enzyme in the leaf, which leads to the formation of red and brown tannin products. Some tannin combines with proteins in the leaf and is thus rendered insoluble. There is hence a decrease in the tannin content of the tea leaf as fermentation proceeds, and often the tannin is reduced to half its original value during fermentation. When the leaf enters the dryer, the oxidising enzyme is inactivated and, between the time of lifting the leaf from the fermenting floor and final drying, very little further loss in water soluble tannin takes place.

During fermentation a steady loss in the soluble solids of the leaf is observed, largely due to the disappearance of soluble tannin. When firing begins, the rate of this loss is greatly reduced.

The protein bodies in the leaf are coagulated by heat in the firing process. The sugars and dextrins are probably, in part, caramellised during firing.

Firing generally inactivates the yeasts and other micro-organisms on the leaf. Fired tea still exhibits a faint enzyme reaction and certain chemical changes, known as post-fermentation, take place after tea is dried. The mellowing or maturing of tea is believed to be the result of these reactions.

It is evident that some aroma is lost in firing, and if the leaf is "stewed" this loss is accentuated. It was at one time thought that some loss of caffeine occurred in the firing process, especially

at high temperatures. This has, however, been shown not to be the case, at any rate with low temperature firing, and no appreciable change in this constituent is registered during firing.

The ideal way to dry wet material is to regulate the removal of moisture so that the rate of transference of water from the centre of the body to the outside is equal to the rate of removal from the outer surface. This can only be realised if the drying be gradual. In drying clay, *e.g.*, in brick making, the brick should first be placed in a cool, moist atmosphere which gradually changes to a hot, dry one. If a wet brick is first placed in a hot, dry atmosphere, the outside is quickly dried and the brick becomes case-hardened, with the result that very high temperature must be employed in order to remove the imprisoned water from the centre of the body.

Similar arguments apply to drying tea, and modern tea drying machines are ideal in that the leaf is submitted first to a blast of warm moist air which steadily becomes hotter and drier as the leaf, gradually drying, passes from the top to the bottom of the machine. If the air ducts or by-passes, which are fitted to some dryers, are opened, then hot, dry air plays on the incoming, wet leaf. The result is case-hardening which is detrimental to the quality of the tea.

In firing tea it is necessary to stop fermentation as quickly as possible (without case-hardening the leaf) otherwise "flat" teas may result. It has been observed that if the temperature of the exhaust air, just above the top tray of the dryer, is 100°F. or thereabouts, "flat" or "stewed" teas are obtained. If the exhaust temperature is about 120°F., pungency and briskness are retained. Observation has shown that with such an exhaust temperature there is practically no tannin loss during firing, indicating that the leaf is heated sufficiently quickly under such conditions to stop fermentation, for all practical purposes, in a very short period of time.

In order to ensure a temperature of 120°F. above the top tray, that below it must be about 140°F., more or less according

to the thickness the leaf is spread on the tray. This big difference in temperature, above and below the tray, results from the fact that considerable heat is used to warm the incoming leaf from about 80° to 120°F. From the second to the bottom tray of the machine the temperature of the leaf is raised fairly steadily, and the air blast accordingly shows a fairly steady rise from below the top tray to the bottom tray, *i.e.*, from about 140° to 180°F. or whatever may be the initial firing temperature.

There is a limit beyond which tea should not be heated, otherwise it is burnt. When leaf is still wet, the evaporation of moisture from its surface tends to keep it cooler than the air blast in which it is drying. Thus, tea may be partly fired at 280°F. without being burnt. When the leaf becomes dry, however, its temperature rises to that of the air blast. Temperatures as low as 200°F. have given teas with a "touch of the fire" when the dry leaf was submitted to such. Tea when dry can be placed in an air blast of 180°F. for a time (half an hour) without being high fired. Such teas are, however, reported on as "dry."

It has been shown that the water soluble matter in the leaf, a factor influencing the thickness of the liquor, is appreciably greater in low fired (180°F.) tea than in high fired (212°F.).

High temperatures and even temperatures about 180°F. are considered to reduce the tea aroma and, on this account, cold drying has been tried. Air, artificially dried, has been passed over leaf at temperatures below 100°F. but, although in this manner fine teas are obtained, they will not keep. Apparently it is necessary to heat leaf to a temperature of about 170°F. before the processes of fermentation are sufficiently slowed down to allow the tea to be stored for any time without "going off." In order to be on the safe side, it is suggested that, in North East India, a temperature of 180°F. be taken as the minimum to which tea should be submitted before it leaves the dryer fully fired.

Dryer capacities.

In order to fire tea in a manner approaching the ideal, it is necessary, first of all, to have sufficient machinery to cope with the crop. Under normal conditions in North East India it may be reckoned that certain machines can satisfactorily deal with certain crops. The table below indicates a fair capacity for suitable combinations of drying machines working at initial temperatures of 180°F. In the case of the E. C. P. machine, the fan speed is reckoned, for the capacity indicated, to be about 350 r.p.m., and of the Empire about 450 r.p.m.

First Firing Machine.	Second Firing Machine.	Season's Crop.
		Mds.
Small E. C. P. ...	Single Tilter	3,000
„ Empire ...	72 in. Imperial Venetian ...	4,000
Large E. C. P. ...	Double Tilter	4,700
„ Empire ...	10 ft. Imperial Venetian ...	5,000

In North East India the double fire is adopted for economic reasons. In Ceylon, tea is usually fired in one process, which is economically possible because the leaf there is much more fully withered than in Assam. Fully withered leaf in North East India contains about 66% moisture whilst in Ceylon leaf is often dried till it contains about 55%. In firing 100 lbs. tea in Assam, about 200 lbs. water have been driven off against about 120 lbs. under Ceylon conditions.

In order to dry tea in North East India in one process, with an initial firing temperature of 180°F., the speed of the trays must be so slow that the output is very small. Other alternatives are a very thin spread, in which case the exhaust temperature rises and efficiency is lost and quality may be reduced, or higher initial temperatures, whereby quality is also lost. Unless a factory is greatly over-machined, firing in one operation is uneconomic with the degree of wither usually obtained in North East India.

Most cases of bad firing are attributable to a shortage of machinery. Here it may be mentioned that the capacity of the

dryer is greatly increased by increasing the fan speed, a question which has already been dealt with in this Journal (part 1, 1929, p. 18). The scheduled speed for an Empire dryer fan is 400 r.p.m. and for an E. C. P. fan 320 r.p.m. Both may be safely increased by 50 r. p. m. It must, however, be remembered that, as the fan speed increases the rate of drying of the leaf increases and, in extreme cases where the drying is very rapid, case-hardening of the leaf may result.

The stoves and air ducts of drying machines should be lagged. The style of lagging suggested is that in general use in Java. The stove and air ducts are surrounded by a light iron frame into which are fitted sheets of some asbestos insulating material at a distance of about one foot from the dryer. The machine is thus surrounded by a layer of air a foot thick, shielded from draughts, and acting as a very efficient insulator, Different methods must be adopted for lagging different types of stoves.

Such lagging will bring about a saving in fuel of about 25%.

The first fire.

Tea must be discharged from the first machine at least "12-annas" dry, and this must be regarded as the most important point in the firing of tea in North East India. Tea discharged at less than "12-annas" is generally "stewed." Three-quarter or "12-anna" fired tea contains 26 to 30% moisture, although this fact is of little help to the practical man in determining what is indicated by "12-anna" tea.

"Twelve-anna" tea is just crisp and any sign of softness in the leaf denotes either that the spreading on the trays is too thick and the machine overloaded, or that the tray speed is too fast, or that the initial temperature is too low. If the machine is overloaded, it usually happens that the temperature above the top tray is less than 120°F. and fermentation is going on appreciably after the leaf enters the machine.

For the best results, leaf should be spread about ¼ inch thick on the trays and should pass through the first dryer in not less than 15 minutes, preferably longer if practicable.

After the need for dropping the leaf from the first machine at least "12-annas" dry, the next most important point is the temperature above the top tray, which should be 120°F. This temperature can be raised by thinner spreading, by higher initial temperatures and greater fan speeds. Under normal conditions of spreading, slowing the tray speed raises the exhaust temperature.

The initial temperature of the first firing machine should be 180°F., if possible. Higher temperatures increase the capacity of the machine but are against quality. On rush days, or when the leaf is so poorly withered that the capacity of the drying machine is severely taxed, it may be necessary to raise the initial temperature to 200° or 220°F. or even higher. This is preferable to discharging the leaf at less than "12-annas" or allowing the exhaust temperature to fall below 120°F.

Of recent years many planters in North East India have regarded the initial temperature of 180°F. as the main point in first firing and have, on this account, neglected the two more important ones. As a result "stewed" teas have often been made and the erroneous conclusion drawn that high initial temperatures make for "briskness" in tea.

It often happens that drying machines get ahead of the leaf and trays run empty whilst a wait is made for fresh supplies of leaf from the fermenting room. An empty layer of trays raises the exhaust temperature considerably above 140°F. and the incoming leaf, meeting this high temperature is thereby liable to be case-hardened. It is preferable to reduce the time of fermentation of part of the next roll by a few minutes, thus avoiding an empty gap in the firing machine, than to put leaf into a machine with exhaust temperatures above 140°F.

The second fire.

The second fire should reduce the moisture content of the leaf from about 28%, assuming the first fire to have to "12-annas," to not more than 3%, which may be regarded as a "16-anna" fire.

As indicated above, when the leaf is dry it quickly gets as hot as the temperature of the air blast in the firing machine. Experiment has shown that, when the tea is fully dried it can be touched with high fire even at 200°F. A safe second-fire temperature is 180°F. and, although leaf may be left in the machine at this temperature after it is completely dry, it will not become high-fired. As previously mentioned, such treatment produces teas which are termed "dry" by tasters and, for the best results, tea should be discharged from the second machine immediately it is fully dried, whatever the intial temperature of the machine. On this account machines of the Tilting Tray and Venetian type are more reliable, under factory conditions, for the second fire than automatic machines of the endless tray type in which complete control ceases after the leaf enters the machine.

If tea is not discharged from the second dryer at full "16-annas" dry there is some risk that may "go off" on keeping. In some factories it is customary to dry to about "15-annas" after which the tea is left in a heap with the idea that it will finish off drying automatically. This is not so and what generally happens in such cases is that the true final drying takes place when the tea is *gap*-ed or *pukka-bhatti*-ed before packing. Since the temperature of this operation is often about 150°F. or lower, it follows that the temperature of the dry leaf may never have been raised to the requisite minimum necessary to give it keeping qualities, especially if low firing temperatures have been employed.

During sorting the tea picks up moisture and the water content rises from about 3 to 6%, at which figure tea should be packed.

Tea stacked in a heap does not pick up much moisture, except round the outside inch or so of the heap. Most of the moisture is taken up during the sorting process and, in the rains, the exposure of the tea during stalk picking is often the cause of a rise of the moisture content to 7 or 8%. In this case tea must be again dried before packing. This process should be carried on at a temperature of 120 to 150°F. and care must be

exercised not to dry the tea too far. The only real check on the moisture content of fired tea is a moisture estimation (see this Journal, pt. II, 1928).

The temperatures mentioned throughout refer to firing machines of the pressure type.

Resumé. The five points of most importance in firing tea in North East India are as follows :—

1. Discharge tea at least "12-annas" dry from first machine.
2. Temperature above top tray of first machine should be 120°F.
3. Discharge tea dried to a full "16-annas" from the second machine.
4. Initial temperature of second machine should be 180°F.
5. Initial temperature of first machine should be 180°F., but may be raised, if necessary.

SOME OBSERVATIONS ON TEA ROOTS.

By

A. C. Tunstall.

The roots of many kinds of flowering plants are known to be infected by fungi which, under ordinary conditions, do no harm to their host. Careful investigation has, indeed, shown that in the case of certain flowering plants the presence of such fungi is necessary for their normal growth. Roots infected by such fungi are termed *mycorrhiza*.

It has long been observed that fungi attack the young feeding roots of the tea plant without causing any apparent damage, though published records in this connection are very few. In 1925, a short note was published in this Journal, (Part IV, 1925.) Their presence was recorded in Ceylon in The Tropical Agriculturist, March 1928, p. 171. Dr. Butler, Director of the Imperial Bureau of Mycology, also records *mycorrhiza* on tea in Nyassaland in his Report on "Some Diseases of Tea and Tobacco in Nyassaland," issued by the Department of Agriculture, Nyassaland, July 1928, p. 19. The matter has now become of special interest in view of the work of Dr. Small, who, in the course of the investigations of root diseases of tea in Ceylon, found a fungus called *Rhizoctonia bataticola* so frequently that he was led to suggest that most of the fungi previously assumed to be the cause of root diseases in tea were really secondary infections following infection of the younger roots by *Rhizoctonia bataticola*. This suggestion was not accepted by Dr. Gadd in Ceylon and our observations in North East India do not support it. *Rhizoctonia bataticola* is not uncommon in North East India, but it is very rarely found on tea.

As there was a possibility that it had previously been overlooked, more recently special attention has been paid to all fungi found in the younger roots of tea.

During 1929 a careful study was made of the roots of the tea bushes growing in the plot adjoining the laboratory at Tocklai. Observations were made fortnightly throughout the year.

The youngest roots of the tea bush are white (*See Fig. 1.* As they get older they become cream coloured and finally red. The red roots are not directly concerned with the absorption of substances from the soil. Their function appears to be the conduction of water and foodstuffs and the storage of the surplus. The absorption of water and substances from the soil is carried out by the white and cream coloured roots. On most green plants the white roots bear a large number of well developed hairs. In the case of the tea plants examined these hairs were very few and as a rule very poorly developed. The maximum length of the root hairs found was .34 m.m. Most of the root hairs observed were present on the white roots a little behind the tip and occasionally near the junction of a white root to a cream one. A few were observed on the cream coloured roots. The climatic conditions did not appear to influence the number or development of the root hairs. As the cream coloured roots change into the red ones the primary cortex is replaced by the secondary bark and the former shrivels up and falls off in patches. The growth of the secondary bark was observed to commence from 29 to 45 mms. from the tips of the white roots.

Fungus mycelium was not observed in the actual root tip but from about 1.5 mms. behind the tip a loose web was found on the surface of the root. This mycelium entered the cortex of the root at many points. The connection between the external mycelium and that inside the cortex was easily traceable in this portion of the root. Infection appears to take place continuously as the root grows. The connection between the internal and external mycelium can be traced at intervals throughout the length of the white and cream coloured roots. The internal mycelium was confined to the primary cortex and was more prevalent in the inner layers of this tissue. No mycelium was observed in the red roots.

The external mycelium is thick walled 4-16μ in diameter. It is sparsely septate. Occasionally, at the ends of hyphae, spherical or pearshaped swellings were observed. The external mycelium did not vary in character throughout the length of the white and cream coloured roots.

The internal mycelium is distantly septate and when young is transparent and regular, measuring 1.5—16μ in. diameter. Its contents are granular. After entering the cortex it runs along the cell wall and penetrates adjoining cells through pits. Later it twists round and round forming coils which frequently fill the cells concerned completely. These coils are present throughout the infected portion of the root. In the older portions of the root however, they become less numerous and their colour becomes pale yellow. At this stage the mycelium does not stain with cotton blue and lactic acid. Eventually the coils totally disintegrate.

In some cells the mycelium produces short bristlelike growths which in turn branch until eventually a tree-like growth is formed. These growths measure 12—51μ in diameter. These structures are characteristic of certain types of mycorrhizal infection and are termed arbuscules. These eventually disintegrate. (See Fig. 2).

From the free mycelium in the cells pouch-like projections, termed vesicles frequently develop (See Fig. 3). Some of these closely resemble the swellings produced on the external mycelium. They are usually spherical but occasionally pearshaped and at times lenticular. They measure 13.9—55.7μ by 18.9—95.5μ. Generally they are 15—40μ by 20—80μ. They may occur scattered or in groups. In the disintergrating primary cortex still adhering to the dead roots similar vesicles are also found. In some cases the contents of these were observed to be divided into bodies resembling zoospores. (See Fig 4).

Another form of mycelium was sometimes noticed. It measured 2—4μ in diameter and formed a loose network. The individual hyphae did not anastomose. This network was not observed to extend beyond the walls of single cells in the outer layers of the cortex.

Most of the mycelium was completely disintegrated before the primary cortex ceased to function. Very little mycelium and a few vesicles were noticed in the dead primary cortex.

In addition to the above routine observations the roots of bushes obtained from other districts, principally in connection with root diseases, were also examined whenever opportunity occurred and similar infection of the feeding roots was observed in every case.

Coils, arbuscules and vesicles are all present on the same mycelium. Figure 2 shows the connection between coils and arbuscules quite clearly. The infection appears to be a single one. Dr. Butler who has frequently observed mycorrhiza on tea plants suggests that the fungus is an *Endogone*.

The fungus did not penetrate the roots of young seedlings (five months old), but in some cases external mycelium was observed. In this connection it is interesting to note that in the case of uninfected seedlings root hairs were present in large numbers, while in the case of older plants, which were in every case infected, the root hairs were very scanty. It appears reasonable to assume that the fungus supplements the work of the root hairs.

The isolation of the fungus in pure culture is very difficult owing to the presence of spore-forming bacteria in the outer layers of the cortex. By adjusting the culture media however, it was found possible to suppress the growth of bacteria sufficiently to enable the fungi to grow. By subsequent transplantation pure cultures of a number of fungi have been obtained.

The fact that the young seedlings are probably immune to infection, and that all the feeding roots of older plants are normally infected render it difficult to make satisfactory inoculations from pure cultures of the fungus. The investigations are proceeding and an endeavour is being made to ascertain the role played by the fungus concerned in the nutrition of the tea plant.

So far as our observations have progressed, there has been nothing to suggest that the fungus *Rhizoctonia bataticola* is commonly found on tea roots in North East India. The fungi associated with the mycorrhiza of tea bear no resemblance to that fungus. Further in the numerous cultures prepared during this investigation no *Rhizoctonia* has been found.

Fig. 1.
A young branch of a tea root.

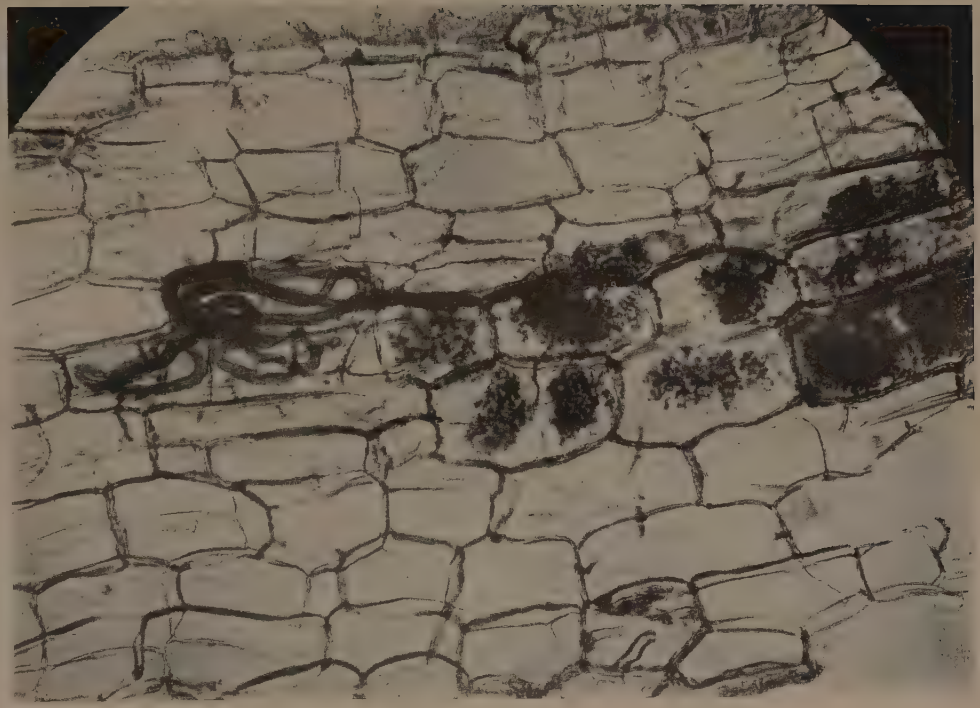


Fig. 2.

A longitudinal section of a small feeding root showing coils of fungus mycelium and the curious branching growths called Arbuscules.

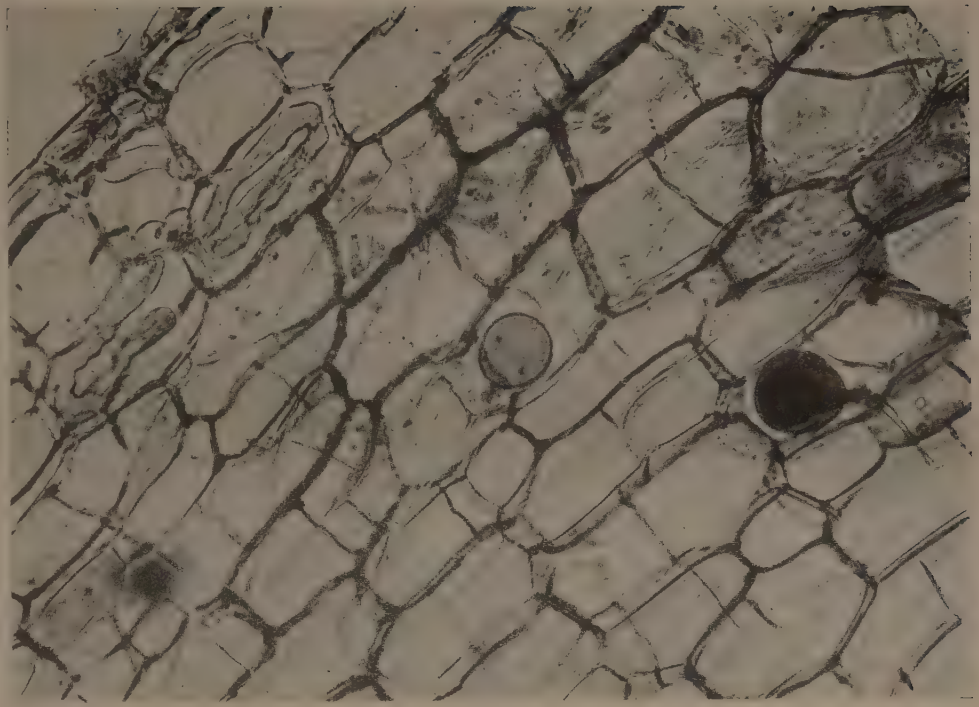


Fig. 3.
A longitudinal section of a small feeding root showing fungus mycelium penetrating the skin.
This section also shows two Vesicles.

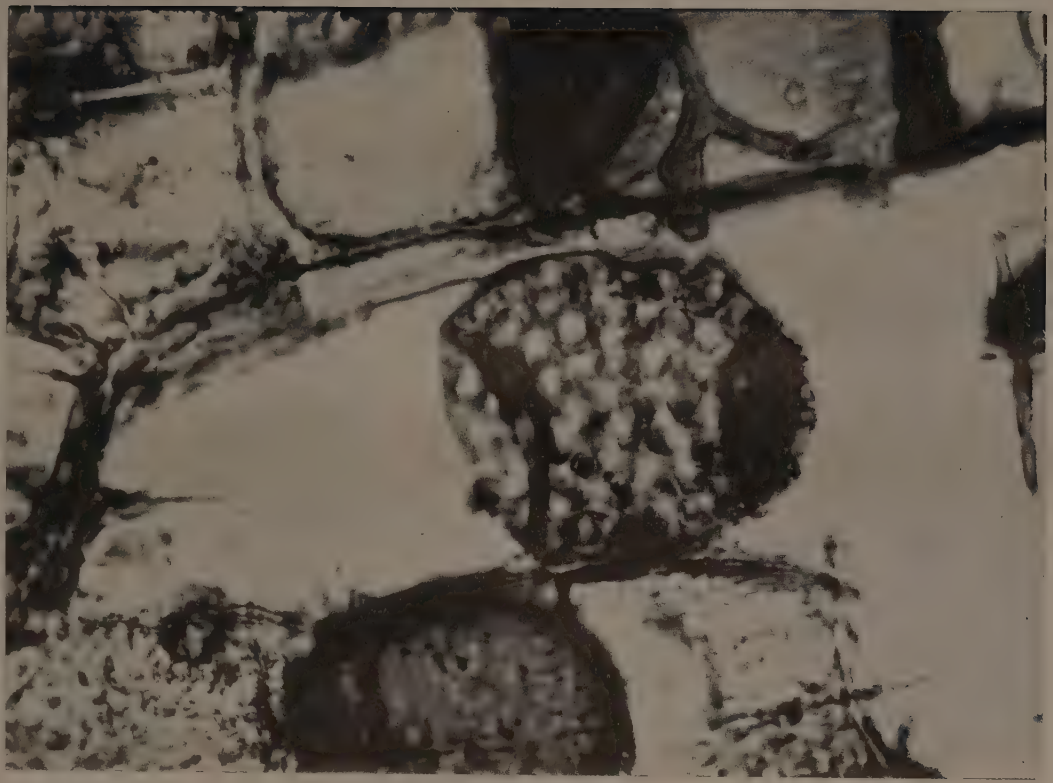


Fig. 4.
A section showing a Vesicle containing immature spores.

METEOROLOGICAL OBSERVATIONS IN NORTH EAST INDIA, 1929.

By

C. R. Harler.

The 1929 season in Assam.

The 1929 season in North East India was a very good one from the point of view of the tea crop, which was about 9% ahead of that for 1928, and about 12% ahead of 1927. The start of the season was especially good for quality, in which respect it was stand out on many gardens. The mid-season months were excellent cropping ones and the back end was also good for crop, but disappointing regarding quality.

Climatic conditions in Assam in 1929 were generally favourable during most of the year. Good late rain fell in 1928, and at the end of that year the soil at Tocklai still contained 15% moisture. Useful showers fell in January and March, 2.82 ins. and 3.23 ins. respectively being recorded for these months at Tocklai.

April was not a very good month, the first twenty days being dry and hot, and the last ten wet and dull. At Tocklai only 2 hours of sunshine were registered in this latter period and 10.28 ins. of rain fell, easily a record for this time of the year. On the 27th. April, 3.61 ins. fell and on the 30th., 2.24 ins., both exceptionally heavy falls for this month. During the wet spell the maximum temperature never rose above 77.3°F. with the result that the tea grew no faster than in the preceding dry period, and Red spider accordingly persisted.

May was wet and cool. Against an average of 9.09 ins. in this month, 14.20 ins. were recorded. Heavy rain also fell in Cachar and Sylhet and floods occurred in several districts in the Surma Valley in this month.

The Monsoon was definitely established on June 19th. in middle Assam, and from this period the wind changed from a northerly direction to steady south-west. Previous to this date, however, heavy falls had been recorded, and in the

Surma Valley between the 4th. and 12th. of June, such heavy rain fell that record floods occurred. An account of the weather conditions leading to this catastrophe is given elsewhere in this Journal (part I, 1929).

July and August were favourable months, although the last three weeks in the latter month were comparatively dry, partly on account of an atmospheric depression which occurred in the west of India, bringing heavy rain and floods in the Punjab and Scind and, at the same time, deflecting and weakening the Monsoon current in the east of India. September and October were favourable months.

In the middle of October the wind from the south slackened off, although the north-east Monsoon was not well established till late in November, which month was accordingly hotter than the average. The year ended at Tocklai about 13 inches ahead in rainfall. Since all of this excess and more, fell before July, the cropping season was if anything drier than usual, as was evidenced by the very good withering conditions generally experienced.

The table below shows the average monthly rainfall at Tocklai in inches, and that recorded in 1929.

Tocklai Rainfall.

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Average ...	0·93	1·47	3·43	7·75	9·09	13 51	16·14	13·16	11·29	4·87	0 97	0·30	82·51
1929 ...	2·82	0·03	3·23	11·72	14·20	18·84	17·84	11 48	9·32	4·66	0·21	0·92	95·27

The 1929 season in the Dooars.

In the Dooars, the early rains were similar to those in Assam. April was very wet, and May precipitation was above the average. Mosquito (*Helopeltis theivora*) showed up badly in June when a crop depression occured, although when growth became rapid again the pest apparently disappeared. August was a very wet and cool month, the average minimum temperature at Sylee being 70.7°F. against in 74.7°F. in 1928. September was also cool compared with the

previous year, the minimum averaging 71.7°F. against 74.1°F. in 1928, although this month was below the average in rainfall. October was exceptionally wet, with 24.12 inches compared with an average of 7.49 for this month. Mosquito was reported to be severe again at the end of the season, although the total crop was a very good one.

For purposes of comparison, the temperature figures at Sylee taken under standard conditions in 1928 and 1929 are shown below, together with the rainfall for these years and the average.

Temperatures and Rainfall at Sylee.

Month.	Maximum 1928.	Minimum 1928.	Maximum 1929.	Minimum 1929.	Rainfall 1928.	Rainfall 1929.	Average Rainfall.
	°F	°F	°F	°F	ins.	ins.	ins.
January ...	73·2	44·5	73·0	47·7	0·04	0 81	0·47
February ...	80·4	52·3	77·8	49·3	0·08	0 29	0·74
March ...	86·7	58·7	87·6	61·1	1·40	2·05	1·12
April ...	89·1	66·5	84·9	66·6	1·78	11·46	3·99
May ...	86·6	69·6	88·3	71·1	16·19	15·20	11·09
June ...	.....	.....	88·9	74·2	31·43	38·34	33·43
July ...	.....	.....	88·7	75·2	36·92	28·32	44·56
August ...	88·9	74·7	90·5	70·5	28·86	43 19	28·21
September ...	88·7	74·1	89·7	71·7	35·07	19·30	28·07
October ...	84·5	68·0	83·2	66·2	21·10	24·12	7·49
November ...	.....	.....	80·3	59·2	2·68	0·75	0·98
December ...	.....	.....	72·7	49·2	*nil*	0·56	0·19

The chief difference between the two seasons is that in 1928, the drought continued till May, whilst in 1929 the rain came much earlier and was greatly above the average in April. In 1929 this early rain, following a sufficient degree of drying of the soil in January, February and March, gave the bushes a good start. In 1928, the prolonged spring drought must have weakened the bushes considerably.

Climate is always a big factor in crop production and the direct effect of temperature and atmospheric moisture cannot generally be counterbalanced.

To some extent climate influences growth indirectly through its effect on the soil, which influence can be lessened. For

example, the water-logging of the soil produced by continuous rain can be reduced by drainage, and the failure of a wet soil to produce nitrates for the food of the bush can be counteracted by artificial manuring at the right time. Similarly the bad effects of an over dry soil can be reduced to some extent by liberal dressings of bulky organic matter and by the nature of the pruning. An over dry soil, like an over wet one will not produce sufficient nitrates for the needs of the bush. Here again the harm may be reduced by manuring with nitrates.

Such measures for the amelioration of the harmful effects of climate are particularly necessary in districts like the Dooars where the weather tends to extremes.

The climatic factor is an important one with regard to tea mosquito attack, but it is possible, by means of the measures indicated above, to reduce the importance of this factor. The exact effect of such measures and the best ways of applying them can only be ascertained by means of direct field experiments.

Sunshine.

Sunshine is one of the most important factors in climate, largely because it raises the average temperature for the day, although the maximum and mean temperatures may be about the same whether the sunny period is long or normal.

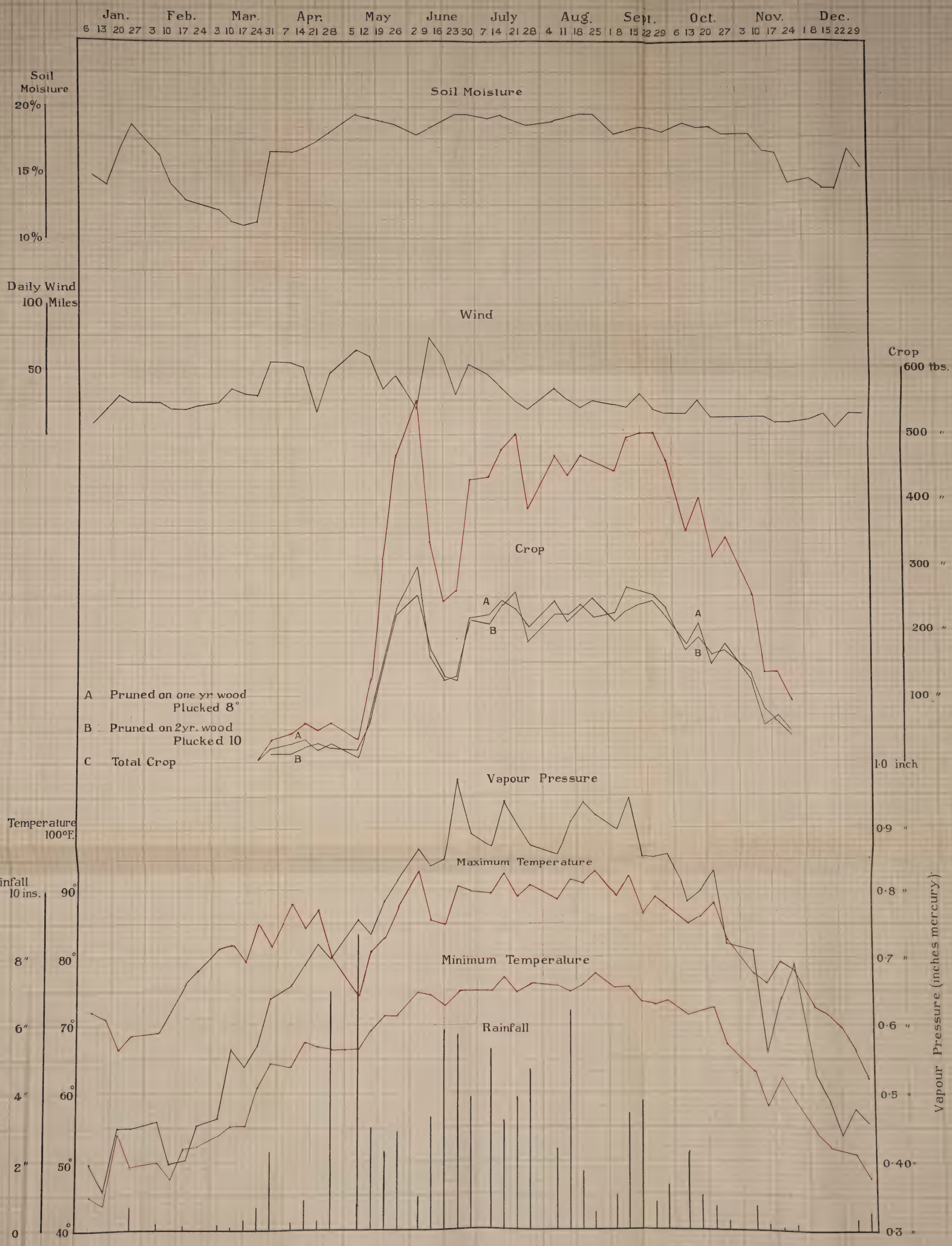
The table below shows the average sunshine in hours per mensem at Tocklai together with the 1929 figures. These latter may be compared with the values recorded Doom Dooma.

Table showing sunshine at Tocklai and Doom Dooma.

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Tocklai Average	164	177	177	141	146	126	124	136	117	180	168	167
1929 ...	150	218	226	134	116	142	117	175	180	139	172	163
Doom-Dooma												
1929 ...	140	192	185	147	118	101	174	180	158	141	161	158

In the Dooars the sunshine is considered to be an important factor in the control of mosquito blight, dull weather in August and September being often recorded when the pest is severe.

SEASON 1929



Observations made at Tocklai Experimental Station.

From 1925, sunshine values have been taken at Sylee, and these, as far as they are available, are put on record in the table below.

Sunshine at Sylee in hours per mensem.

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1925 ...	...	...	...	118	101	124	94	96	86	...	...	...
1926 ...	...	...	...	180	147	91	8	127	170	...	...	...
1927 ...	...	...	190	217	216	144	114	149	144	223	196	142
1928 ...	190	232	255	109	169	91	111	123	133	171	...	...
1929 ...	196	221	275	192	196	112	104	144	207	187	111	170

It is unsafe to draw any conclusions from the limited data available, but it will be observed that 1928, a bad mosquito year, was not unduly dull in August and September, although 1925, another bad year, was certainly short of bright sunshine in these months.

The weather chart for 1929.

The weather chart, shown opposite, is drawn on lines similar to those adopted in the Meteorological Reports for the past ten years.

The top curve shows the soil moisture which, but for a short spell in March, was never below a satisfactory figure. The samples for the moisture estimation are taken from the top six inches of soil, so that a value of 10% or so in his stratum may generally be taken to denote that at a few inches below the moisture is ample. With the Tocklai soil type about 15% is reckoned as a satisfactory moisture content.

The second curve shows the daily wind recorded in miles, averaged from the weekly readings. For the fifth year in succession the absence of high winds in the spring is to be recorded.

The leaf from the Tocklai clearance, an area about 2½ acres, is taken for purposes of correlation with the weather. The top red curve shows the total weekly leaf from this area. The other two curves show the leaf from the annually and biennially pruned halves which make up the clearance. In the season under discussion, both areas were pruned and it will be noticed that the tea cut on two year wood (*i.e.*, biennially pruned) gave practically the same crop as that cut on one year wood.

The serious falling off in the crop in June after excellent returns in the first big flush is the most notable feature of the crop curve. Some years ago, when fewer records were available, it was supposed that this falling off might be due to unfavourable conditions (see this Journal, pt. IV, 1922, p. 181). With the observations made over ten seasons now available, it is evident that when the early crop is heavy there is a marked depression after the big flush.

When the season starts badly this depression does not occur, partly because of the smallness of the early crop and partly on account of the delayed flush which is gathered in three or four weeks instead of in two or three weeks when the season starts well. Reference to the crop and weather curves published from 1922 onwards illustrates this point in connection with the June crop depression.

Thus, in 1928 the start was a bad one and the May-June flush poor. The result was that the crop showed a steady rise to August. A good start would have given a big crop in May-June followed by a comparatively poor period before the next big flush in July.

In 1927 the start was good and June gave very big returns, the second half of this month giving more than double the leaf obtained in the first half of July. In 1926 similar conditions held. The 1925 season started wet and cold and poor crops were taken in June with no depression following. Both 1924 and 1923 started badly, in the former year the June flush was hardly marked at all, and in the latter so slightly that the following depression was not accentuated.

A poor start tends to produce more even growth distributed from May onwards, with no lull in June or July. With rapid early growth the appearance of mosquito is likely to be noticeable in the lull which follows, and it thus happens that, in the Dooars and other mosquito areas, the pest will be more apparent early in the season if the start be good. The effect of the good start on the vigour of the bushes is, however, usually seen in the disappearance of mosquito when growth again starts or, at any rate, in the collection of a good crop in spite of mosquito.

TEA IN NORTH EAST INDIA, IV.

BY

P. H. CARPENTER.

(Concluded from part IV, 1929.)

CULTIVATION.

Practically all cultivation in tea is done by hand, for the closeness of the bushes makes the employment of mechanical cultivators as at present constructed, almost an impossibility. Recently small bullock-drawn cultivators have been used on gardens which are on the flat, and attempts are being made to introduce cultivators driven by internal combustion engines.

It was early recognized that the more a garden is cultivated the greater the crop, and from this came the idea that "tincture of steel" should be the first consideration in garden operations. A deep hoe to a depth of six or nine inches was put in during the cold weather, and a light hoe to a depth of three or four inches about once every month or two afterwards. With the rains the weeds grew quickly and often got ahead of the cultivation by August, and in some cases the garden disappeared beneath jungle before the hoeing men caught up on it when the rains ceased.

In Ceylon where there is no marked dry spell during which the weeds cease to grow, the soil is clean weeded and the weeds either burnt on the spot or carried off and dried. All this is organic matter lost to the soil but this loss is evidently preferable to a garden over-run with weeds.

With the shortage of labour in North-East India, the posibility of a monthly round of hoeing on a garden became out of the question and the weeds, especially undesirable thatch and deep rooting grasses, spread through the tea areas.

In 1922 extensive cultivation experiments were started at the Tocklai Experimental Station and although this work is still in progress, all the results point to the fact that it is the harmful effect of the weeds rather than the beneficial effect of stirring the soil during cultivation, that influences the tea crop. Accordingly it is becoming the custom to leave the sides of the bushes so that they cover the soil and tend to keep down weed growth. It has been found that such a procedure not only reduces the need for hoeing but also keeps the soil in good tilth.

In addition to deep cultivation once a year and light hoeing, it is usual to fork round the bushes once a year in order to remove ferns and grasses which collect there and escape the ordinary weeding.

Trenching was at one time largely practised. A trench up to 18 inches deep was cut between the bushes and prunings or green crops buried, which process is a good one on a soil with a pan. The tendency nowadays is to disturb the soil as little as possible, provided it is free from weeds, and trenching and deep cultivation are much less employed than formerly.

Manuring.

The systematic manuring of tea in North East India is a recent innovation. The first manuring was top dressings of peat soil obtained from *hullahs* and *bheels*. Later on cattle manure was used, although only within the last decade or so has this most valuable manure been carefully collected and stored in properly constructed covered pits. The use of oilcake followed and, later on, animal meal. There has always been shown a preference for organic mauures and only recently has the free use of chemical manures become common. Now the use of artificials threatens to supersed almost entirely the use of the more expensive organic manures.

The use of imported manures is increasing rapidly as is shown by the following table which indicates annual quantities

sent from Calcutta into North East India during the eleven years from 1915 to 1925 :—

Year.	*Tons.*
1915	7,700
1916	9,150
1917	3,300
1918	5,250
1919	8,750
1920	8,200
1921	3,870
1922	12,200
1923	15,600
1924	20,000
1925	20,000

During the war there were at times difficulties in obtaining manures. The falling off in manure purchases in 1921 was due to the slump in tea.

The price of manure per ton in 1925 was about the same as in 1915, the orders for which were delivered at pre-war prices. This is due to the fact that cheap chemical manures are now being purchased in place of expensive organic manures. It must be remembered that the present purchases represent a much greater amount of plant food than the previous ones which included large quantities of organic manures.

The tea soils of North East India require constant additions of nitrogenous manures and of organic matter. From extensive field experiments it has been observed that applications of potash or phosphoric acid alone generally give little or no crop increase. On sandy soils, nitrogen is best applied with potash and on clays with phosphoric acid.

Nitrogen increases leaf production and is for that reason the main constituent of all our manure mixtures. Potash, it has been found, tends to keep the bush free from fungus attack and to prolong the growing period so that the bush flushes later than it otherwise would. Phosphoric acid tends to steady up the

flushing and in that manner makes for slower growth and better tea. It is the general opinion that much of this plant food, however, makes for stalky teas.

Organic matter is added to the soil as cattle manure, if it is available, or as green crops. The difficulty of collecting cattle manure is great so that its use is limited. During recent years green crops have been freely grown. These are either either eight week crops like dhaincha (*Sesbania aculeata*), cowpeas (*Vigna catjang*), mati kalai (*Phaseolus* spp.), sunn-hemp (*Crotalaria juncea*), soy bean (*Glysine hispida*), which are planted in the spring and hoed in May or June before the heavy plucking months; or rahar (*Cajanus indicus*) which is sown is every second or third row and buried at the end of the season. In other cases Boga medeloa (*Tephrosia candida*) is used and left up two years or Indigofera which is left up three to five years.

Several other crops have been tried but those mentioned above are the ones usually employed.

Many gardens at present are manured in cycles such as the following :—

1. Rock phosphate and a six-week green crop or 5 tons cattle manure per acre.
2. Chemical mixture giving—
   30 lbs. nitrogen and
   30 lbs. potash per acre.
3. Rahar or Boga medeloa and chemical mixture forked round bushes giving—
   30 lbs. nitrogen, 20 lbs. potash and
   20 lbs. phosphoric acid per acre.
   Cut down and bury rahar at the end of the season.
4. Chemical mixture as in 3.
   Bury Boga medeloa at the end of the season.
5. Chemical mixture as in 3.

The manures are added in the spring. Rahar and Boga medeloa are lopped and thinned out at intervals, for excessive

foliage on the green crop not only makes plucking difficult but also depresses the tea crop.

The amount spent per acre in manures is steadily increasing and nowadays the figure often reaches Rs. 25 and in some cases much more.

The manuring of seed gardens is a different problem since the crop here is seed, not leaf. Accordingly large doses of phosphoric acid and potash are given in August when the seed begins to fill. Nurseries are not often manured, because they are usually put out in virgin soil.

Lime is seldom used now on tea in North East India. The history of the use and disuse of lime is an interesting one. The earliest scientific advice was against the use of lime, but when the soil acidity was studied and bacteriologists had shown that nitrogen fixation took place best in neutral or faintly alkaline soils, the use of small doses of lime (about 800 lb. per acre every 5 years) was advised. In the meantime field experiments were carried out with doses of lime varying from a quarter of a ton to 40 feet square, but as the trees develop, planting at this distance in most cases a small but definite crop depression was recorded. The result is that now lime is only advised on extremely acid soils or because of its action on the soil tilth.

Shade trees are grown amongst the tea on most gardens partly for the benefit of the shade and partly for the beneficial effect of the leaf droppings. They are usually planted about 30 to 40 feet square, but as the trees develop, planting at this distance is often found to be too close. About 50 feet apart is recommended for most districts. Too dense shade lowers both quality and crop. Shade is needed mostly during the spring and autumn months. Shade is needed more in areas where the light leaved variety of tea is grown than where the Burma or dark leaved variety is grown.

The most common shade tree is the Sau (*Albizzia stipulata*), a quick-growing tree which, however, easily cankers. The Ceylon Sau (*Albizzia moluccana*) is not popular because of its

dense shade in the cold weather and its consequent heavy call on the soil moisture reserves. *Albizzia lebbec*, *A. procera*, *Dalbergia assamica*, *D. Sissu* and *Derris robusta* are also in common use.

Many of the tea areas are now over fifty years old and the bushes have been heavy pruned many times with the result that the frames of the bushes are represented by gnarled branches bearing the scars of past prunings. Such bushes suffer from fungus diseases and the older wood is usually covered with lichens. It is often desirable to rest such areas. To do this the bushes are pruned in the cold weather and then left unplucked during the season, although the soil is kept clean. At the end of the season the bushes are again pruned and where this is done it is usually noticed that not only is the new wood strong and thick but the old wood has thrown off much of its parasitic growth.

Pests and blights.

The tea bush is subject to attack by many insect pests and fungus diseases, and the list of known pests and diseases is already formidable.

The most serious and at the same time widespread insect pest is undoubtedly the tea "Mosquito" Bug (*Helopeltis theivora*), whilst the Red Spider, though perhaps not so serious is even more widespread than the former.

Amongst the Orthoptera, crickets (*Branchytypes portentosus*) often give considerable trouble, more particularly in nurseries and heavily pruned tea.

Of beetle pests of tea (*Coleoptera*), the most important is the Orange or Peal's Beetle (*Diapromorpha melanopus*), which by eating partly through the succulent shoot of the flush, causes the upper portion to die off. Cockchafer grubs (*Lachnosterna* spp.) attack the roots of the plant, and may do considerable damage in nurseries.

The Shot-hole Borer (*Xyleborus fornicatus*), so obnoxious in Ceylon, is, fortunately, unknown in North East India.

The list of caterpillar pests (*Lepidoptera*) of the tea plants is a long one, amongst which those of the Faggot and Bag Worms (*Clania* spp.), Bark-eaters (*Arbela* spp.), Red Slug (*Heterusia magnifica*), Red Borer (*Zeuzera coffeae*), Looper (*Biston suppressaria*), Bunch Caterpillar (*Andraca bipunctata*), Sandwich Caterpillar (*Agriophora rhombota*), Leaf Rollers (*Homona menciana, Grecilleria theivora*) and Nettle Grubs (*Thosea* spp.) are the most important. The caterpillar of one moth (*Blastobasis spermogena*) lives inside the tea seed. It is a fact worthy of note that all the caterpillar pests of tea turn into moths, and that up to the present no butterfly pest of tea is known.

No member of the order Hymenoptera is known to be an actual pest of the tea bush, though ants of various species, by protecting scale insects and tea apis, contribute indirectly to the amount of damage done.

The order Hemiptera includes the insects which occasion most concern to the tea industry. The tea "Mosquito" Bug (*Helopeltis theivora*), the arch enemy of the tea plant, occurs in practically all districts, but is particularly dangerous in the Dooars, Terai and the Surma Valley. The pest, when severe, may cause the bushes to stop flushing entirely. Green-fly (*Empoasca flavescens*) is credited with producing a stunting effect on the shoots but at the same time improving quality. The tea aphis (*Toxoptera theaecola*), by curling and stunting the young growing shoots, may cause a considerable check to young plants in the nursery, and to bushes commencing to grow after pruning. Scale insects do a considerable amount of damage in the hill district of Darjeeling, though in the plains the more vigorous growth of the bushes reduces the damage done by these insects. *Chionaspis manni*, in particular, does much damage in Darjeeling by sucking the downward stream of sap from the branches and so causing the branch to be starved below the point of attack. Thus a branch half an inch in diameter above the point of attack may be only an eighth of an inch in diameter below, and the growth of the bush is seriously interfered with. The tea mealy bug (*Dactylopius theœcola*),

which attacks the roots of the plant, is also a noteworthy pest of tea in Darjeeling. The tea-seed bug (*Poecilocoris latus*), while scarcely affecting the plucking bush, is a serious pest in tea-seed gardens, as by puncturing the seed it permits of the entrance of fungi to the interior, with ultimate destruction of the seed.

The order Thysanoptera, or Thrips, includes a pest of tea which causes much damage in Darjeeling, *viz.*, the common Thrips of tea (*Physothrips setiventris*). This pest causes very severe stunting of the flush, thereby reducing quantity and, by making the young leaf papery and brittle, undoubtedly affects quality also.

Amongst the Pseudo-neuroptera, Termites or White Ants are often troublesome, by swarming into the bush primarily in search of dead pruning snags, plucked shoots which have died back, etc., and ultimately extending their ravage to the entire frames of the bush. Of the varieties found, Odontotermes, which lives in the ground, is most wide-spread, but attack by varieties of Calotermes nesting in the bushes, so serious in Ceylon, is practically unknown though it has been found to occur in tea seed gardens in the Surma Valley.

Various mites (*Arachnidea*) attack the tea plants, the most important of which is Red Spider (*Tetranychus bioculatus*), which occurs in all districts, particularly upon old and weak tea. The Scarlet Mite (*Brevipelpus*), Pink Mite (*Phytoptus theæ*), and Yellow Mite (*Tarsonymus translucens*) do damage occasionally.

In the case of the more serious pests, the tea mosquito bug, red spider and thrips, adequate control measures have yet to be devised. Insecticides play their part in reducing the amount of damage done, but research is pointing more and more to the fact of the condition of the plant as regards its resistance to the pests as the main controlling factor, and the modification of cultural operations to increase this resistance is receiving increased attention.

Damage by caterpillar pests, termites, etc., has been much reduced in late years by improved methods of cultivation pruning, etc., and in many cases modifications of cultural operations, based on an increasing knowledge of the biology of the pests, are found to be entirely adequate as a means of control.

The fungus diseases which attack the tea plant may be divided into two categories. Those which are usually associated with lack of vigour in the host plant and those in which this association is not readily traceable. In the former group the commonest diseases are Brown Blight (*Glomererella cingulata* [Stonem] S. & V. S. = *Colletotrichum camelliæ*, Mass.) and Grey Blight (*Pestalozzia theæ*, Sawads). The Alga (*Cephaleuros mycoidea*, Kart.) which causes Red Rust is also very commonly found on debilitated bushes. *Sphærostilbe repens* frequently attacks bushes growing on water-logged or badly aerated soil and *Thyridaria tarda*, Banc. (*Diplodia*) is often found on bushes growing on soils subject to drought. A considerable number of species attack individual branches rendered moribund by other causes such as unsatisfactory systems of pruning and plucking. By studying the life-histories of these fungi in their relationship to the tea plant it has been found possible to reduce the loss due to their action to a great extent by modifications in the manuring, plucking and pruning.

The diseases which so far it has not been found possible to connect definitely with the condition of the tea bush include Blister Blight (*Exobasidium vexans*, Massee) and Copper Blight (*Lœstadia Theœ*, Rac., *Lœstadia camelliæ*, Cke.) on the leaves, various species of *Corticium*, *Nectria cinnabarina* and Thread Blight on the steams, and *Fomes lamaœnsis*, *Ustulina zonata* and *Rosellinia arcuata* on the roots. Blister Blight is the most serious of the leaf diseases in this country. This disease has been known in Upper Assam from the early days of the tea industry. It was found in other districts for many years. In 1907 or 1908 it reached the Darjeeling district and at the same time was found in isolated gardens in the Bhutan hills as well as certain gardens in the Darrang district and the Dooars. In

November and December 1926 the disease appeared simultaneously on a number of widely separated gardens in the Surma Valley. The spores of the fungus are distributed by the wind and it has only been found possible to eradicate it from well isolated gardens. The disease only attacks succulent growth, and it has been found possible to protect by spraying, tea on which the undue loss of such growth will cause severe damage. Copper Blight is rarely sufficiently severe to warrant special treatment.

Of the stem diseases the most severe is Black Rot (*Corticium invisum*), but this and other species of *Corticium* and Thread Blight are readily removed by spraying with fungicides, *e.g.*, lime-sulphur solution. *Nectria cinnabarina,* however, requires to be cut out; fortunately this disease is comparatively rare.

The root diseases not associated with lack of vigour in the plant are generally found to originate in decaying wood such as tree stumps, fence posts, remains of wooden bridges, etc. The only satisfactory treatment is the removal of the dead bushes together with all dead wood from the soil in their vicinity.

It has been found by practical experiment that the application of lime-sulphur solution to the tea bushes often results in increase in crop and its use is becoming more and more general. Experience has shown that the spray fluid can be economically distributed by means of knapsack sprayers.

In general the tendency of the research work on fungus and other diseases of vegetable origin has been to emphasize the importance of rendering the tea plant resistant by cultural methods. The primary object of the work on disease treatment has been the improvement in the outturn of the tea bush and in many cases serious outbreaks of disease have indirectly led to a general improvement in the gardens concerned.

Manufacture.

Most tea factories in Assam are lofty single storied buildings with one or more withering houses nearby. In Darjeeling and the Dooars the factories usually have two or three stories, the

upper ones being used as withering lofts, in which case separate, outside withering space is either reduced or entirely dispensed with.

The power used in tea factories is still mainly steam, although new installations are practically always oil engines. A few gas engines have been installed. In a few Dooars gardens and in many Darjeeling ones, water turbines are used. In one or two cases only, is hydro-electric power employed. Power is needed to turn the rollers, to work the trays and fans of the drying machines and the sorting apparatus.

The ground floor of the factory is divided into three or four compartments, the rolling room, the fermenting room, the firing room and the sorting room. In Assam many of the fermenting rooms are apart from the factory and placed sometimes under a leaf house, for coolness. In some factories the rolling and fermenting rooms are one. The firing room is generally in the middle of the factory and separated from the rolling room by a brick wall which serves to stop the heat from passing into the rolling room.

The manufacture of tea leaf consists of four processes, withering, rolling, fermenting and firing. The chemical and biological changes going on during manufacture are but incompletely understood. Since tea is drunk largely on account of its tannin content, most of the chemical work on manufacture has been in connection with the changes undergone by this substance. During the rolling of the leaf, the cells are broken and the sap exposed to the air with the result that some of the tannin is oxidised with the aid of enzymes in the leaf. During fermentation, the processes started in the rolling are continued. These reactions are stopped by firing the leaf.

The loss of soluble tannin during manufacture is shown below. The figures represent one particular case but may be taken as indicative.

Fresh leaf contains	22·2	% tannen
Withered leaf contains	22·2	,, ,,
Fermented leaf contains	12·9	,, ,,
Fired leaf contains	12·0	,, ,,

As the leaf is plucked in the garden it is put into a basket by the plucking women who carry it to the factory or to a weighing shed, at the end of the morning, and again at the end of the day's work. When the leaf is heaped up in the basket it tends to get hot and turn red. Red leaf makes poor tea and, in order to avoid this, pluckers are instructed to pack the leaf lightly and to turn it over in the basket from time to time.

When the leaf is weighed, it is taken to the withering house and spread. In Assam the leaf house or withering shed is usually of the "chung" type. This type consists in a series of floors about 3 feet apart. There may be as many as ten tiers of floors in a shed. The newer withering sheds are made of iron, are tin roofed and fitted with weather boards. The floors themselves are made of strips of bamboo covered with hessian. This type of leaf house is the most expensive but general experience shows that it is the best so far as getting a good wither on the leaf is concerned.

The other type of withering shed consists of a series of narrow racks of wire netting, each rack about 6 inches from the next and each series reaching a height of about 6 feet. This type of shed takes more leaf than the chung type but the wither obtained is often an uneven one.

When the factory is fitted with a loft it is usual to have narrow wire racks. The loft is generally heated by the hot air coming from the firing machine below and this air flows through a duct into the centre of the loft and is drawn to either end by means of fans.

The leaf is spread thinly on the racks. With a wire rack about 9 square feet are allowed for one pound of green leaf but with a "chung" a greater area is usually given. The thickness of spreading is naturally controlled by the quantity of leaf brought in and the spreading space available, and on many days spreading is by no means ideal. It is, however, uneconomical to provide enough withering space to cope with the heaviest days.

It is necessary for the leaf to wither in order that it shall take on the twist in rolling which custom demands in tea. Of late years, broken teas have been in greater demand than leafy teas, since the quick infusion given by a flaky leaf is required rather than the slower infusion given by a well twisted leaf. On this account leaf is not so well physically withered as it was some years ago. Working at temperatures averaging 80°F. it has been found that in North East India a good wither is obtained in about 18 to 24 hours if 100 lbs. leaf dry to about 65 lbs. The fresh leaf contains about 77% moisture so that the above degree of signifies that withered leaf contains about 65% moisture.

After withering, the leaf is rolled in brass rollers which revolve in a rotary manner in imitation of the hand process. The roller makes 60 to 70 revolutions per minute and takes as much as 360 lbs. of leaf in each charge. Rollers are fitted with pressure caps which can be lowered so that the leaf is rolled under pressure.

As soon as the rolling starts the leaf is broken and the fermentation process begins. On this account every attempt is made to keep the rolling room cool, for at high temperatures the control of fermentation is difficult.

The first roll is generally a light one lasting for about 30 minutes with little or no pressure. At the end of this time a trap door at the bottom of the roller is opened and the leaf drops into a trolley. During the rolling the leaf has formed into balls and has become warm. In order to cool it and break the balls to ensure even fermentation, the leaf is now put through a sieve either of the rotary or table type. This sieve is a coarse one varying from 3-mesh in some factories to 6-mesh in others. The balls are broken and the finer leaves and the buds fall through the sieve and are taken to ferment separately. In this fine leaf the "tip" is found.

The coarse leaf is taken back to the rollers and is again rolled with pressure. Hard rolling makes strong tea but also exposes stalk.

The fermenting room must be kept cool, damp and clean. The cement floor on which the rolled leaf is spread is washed down with water from time to time. The leaf is spread about 2½ inches thick and is left to ferment for periods varying from two to three hours. The time of fermention varies according to the degree of wither, to the temperature of the room and to the thickness of the spreading. Experience has shown that as fermentation proceeds the tea gathers strength but tends to lose pungency and briskness. It is important to take up the tea for firing just at the right time, determined partly by the aroma or "nose" of the leaf and partly by its colour, which should be red.

Tea is dried or fired in machines which are actually endless perforated metal trays through which hot air is blown. The air is fan-drawn through or across tubes, heated in a furnace, and then forced into the bottom of the dryer where it first meets the nearly dry tea and then passes up to the moister tea till it finally meets the incoming tea fresh from the fermenting room. The hot air as it enters the dryer should be about 180-200°F. and as it leaves it should not be cooler than 120°F. which temperature ensures the stopping of the fermentation process.

Tea is dried in North East India in two processes. The first fire is to " 12 annas," *i.e.*, three-quarter of the moisture is driven off and the leaf then contains about 30% moisture. The second fire is usually carried out in smaller machines at 180°F. and the tea dried to about 3% moisture.

When the tea comes from the dryer it is a mixture of long leaf and fine leaf. This mixture is now sorted. In factories where the grading of the tea is a special point, the leaf is first put through long rotary sieves which make about 25 revolutions per minute. The first sieve is usually of 13 or 14-mesh and the tea which falls is composed of the fine broken leaf and " tip." This mixture goes by the name of Broken Orange Pekoe or B. O. P. The spill from the first sieve then goes through a second one of 11 or 12 mesh and the leaf which falls is longer than that from the first sifting and composed largely of the first leaf

of the shoot. This is called Orange Pekoe or O. P. The spill is then put through a breaking machine and again sifted, this time probably through a mechanical sorter giving coarse grades resulting from the second and third leaves and the stalk. These coarser grades are known as Pekoe, Pekoe Souchong and Broken Pekoe Souchong. The fine flakes are known as Fannings and the powdered tea as Dust. There are other grades such as Flowery Orange Pekoe, Pekoe Fannings and so on, although only a few grades are very definitely demarcated. During the grading process stalk is carefully picked out either by hand or by stalk extracting machines.

It is usual to bulk the tea and then to pass it quickly through a dryer at about 150°F. before it is packed. During the sorting, tea picks up moisture and often by the time it is ready for packing contains 8-10% moisture. The drying before packing is designed to reduce the moisture content to 6% which is sufficient to allow for mellowing of the tea but not enough to allow the tea to go mouldy. The tea is packed mechanically in lead or aluminium lined chests generally of three ply wood. When sufficient tea to make an invoice or "break" has been made, it is sent to Calcutta or London for sale.

Work of the Scientific Dpartment.

The laboratories of the Scientific Department are situated at Tocklai in the Jorhat district of Assam. A small laboratory is also in use at the Indian Museum, Calcutta. At Tocklai there are only 4½ acres under tea but the main field work is carried on at Borbhetta about 1½ miles away, where 52 acres are out under tea for experiment.

The fundamental laboratory problems are chemical ones and problems of the Mycological, Bacteriological and Entomological Departments in many cases eventually become chemical ones. This is more so since the possibility of disease treatment through the treatment of the bush has been recognized.

A detailed soil survey of the tea districts has been made and this is backed by field trials carried out in various districts and on all classes of soils. The result is that manurial suggestions can be made with great confidence. It is the custom for a garden to obtain scientific advice before it embarks on a manurial programme.

The soil acidity problem is a major one and the limits of acidity and alkalinity tolerated by tea have been indefinitely fixed. Closely allied with this study is that of the work on soil bacteria.

The study of the changes going on during tea manufacture is now greatly assisted by a small, electrically driven experimental factory at Tocklai. Most of the study so far has been related to tea tannin and its changes. Experiments in factories are carried on throughout the season and the empirical side of tea manufacture is fairly well understood.

In the Mycological and Entomological laboratories the life-histories of all the pests and blights common to tea have been studied and worked out. The control methods resemble those used in other branches of agriculture but continuous study is being devoted to the relationship of the disease to the condition of the bush.

At Borbhetta, pruning, plucking, manuring and cultivation experiments are made. All the tea at Borbhetta is young tea so that the problems of pruning old tea cannot be studied there. The plucking experiments, which are in progress, go to show that this operation is perhaps the most difficult on the garden in that it requires much discretion and experience. The incorrect plucking of an area may lose more crop than can be gained by liberal manuring.

The use of phosphatic manures has been extensively studied, both in connection with their influence on green crops and on tea. The trial of nitrogenous manures on tea shows that the bush

responds well year after year to chemical manures showing a much greater increase with this type of manure than with organic manures. Potash and phosphoric acid used alone have been shown to give no appreciable increase in leaf.

So far as cultivation is concerned, all experiments go to show that the keeping of the soil clean rather than soil disturbance is what is needed.

During the cold weather and in the rains, lecture courses are held for planters. These courses consist in lectures on chemistry, entomology, bacteriology and mycology as applied to practical tea problems, and also in field demonstrations.